THE GREEN CATALYST NEXUS: A COMPOSITE MODEL FOR DRIVING GREEN LOGISTICS PERFORMANCE IN YANGZHOU'S MANUFACTURING

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Received: November 19, 2025 **Revised: February 24, 2026** **Accepted: March 24, 2026**

ABSTRACT

This research investigates the extent to which the Green Catalyst Nexus (GCN) incentivizes green logistics performance in manufacturing industries in China. The GCN represents the set of environmental laws and regulations, regulatory policies, market drivers in finance, and the state of corporate environmental management reputation**,** which incentivizes green innovations. A quantitative design was used for PLS-SEM analysis. Sample data was collected from 408 manufacturing managers in Yangzhou, China. This study investigates the direct influence of GCN on green logistics and examines the mediating effects of Green Innovation Capability (GIC) and Environmental Management Practices (EMP). The results show that GCN has a significant impact on Green Innovation Capability (GIC) (β = 0.922, $p < 0.001$) and Environmental Management Practices (EMP) (β = 0.347, $p < 0.001$). EMP has a significant positive impact on green logistics performance (β = 0.592, $p < 0.001$) and GCN impacts on green logistics performance directly (β = 0.275, p = 0.0015). GIC does not have a direct impact on green logistics (β = 0.084, p = 0.388) but does so indirectly through EMP indicating partial mediation. The results show that green logistics performance is not only dependent on innovation but also on the integration of environmental policy, innovation and management practices.

Keywords:

Green Catalyst Nexus, Green Innovation Capability, Environmental Management Practices, Green Logistics

Research Background

The industrial sector in developing economies like China faces growing environmental challenges due to economic growth, resource-heavy production, and stricter regulations (Li et al., 2023). To promote economic growth and sustainable environmental development, Green Supply Chain Management (GSCM) and green logistics can guide efforts toward balance. Implementing green logistics practices can cut carbon dioxide emissions, boost fuel efficiency, lower costs, and ensure smooth operations (Mohammad & Daniell, 2022).

The complex interrelationships between government policies, market dynamics, stakeholder pressures, and internal organizational capabilities jointly drive the practice of green logistics, and together determine the direction of green logistics practice (Yang et al., 2021). Government fiscal strategies, fiscal incentives, and corporate environmental responsibility initiatives are catalysts for sustainable practices. These factors will drive the development process of the enterprise. Strong green innovation capabilities (GIC) and effective environmental management practices (EMP) can improve a company's logistics performance (Yu et al., 2023).

Prior research demonstrates that GSCM adoption enhances both environmental and economic outcomes in manufacturing sectors (Deng et al., 2020). In China's manufacturing industry, there is a limited understanding of how environmental factors, innovation, and management interact and how to foster these to enhance logistics performance (Juan et al., 2019). This study developed and tested a conceptual framework that links GCNs (including government policies, market demand, organizational strategies, and financial resources) with green logistics performance, mediated by GIC and EMP. Using PLS-SEM, analyze the direct and indirect effects that affect logistics performance (Hair et al., 2019).

This article will theoretically analyze how environmental catalysts can drive logistics performance through innovation and management practices. It will provide valuable insights for business decision-makers and leaders. Designing strategies and incentive measures will jointly promote the sustainable development of the manufacturing supply chain.

Research Objectives

1. To examine the influence of the Green Catalyst Nexus (GCN) on green logistics performance in China’s manufacturing industry.
2. To investigate the mediating roles of Green Innovation Capability (GIC) and Environmental Management Practices (EMP) in the relationship between the Green Catalyst Nexus (GCN) and green logistics performance.

Conceptual Framework

This study employs a second-order composite modeling method to investigate how the green catalyst network (GCN) influences green logistics performance (GL). It also assesses the roles of Green Innovation Capability (GIC) and Environmental Management Practice (EMP) as mediators. In the first-order structure, GCN includes government environmental policies (GEP), ecological performance orientation (EPO), financial benefits of green compliance (FAGC), company-wide green compliance practices (FWPG), and environmental and social reputation (SRE). These factors act as catalysts and form the latent variables of GCN, fostering innovative and management practices.

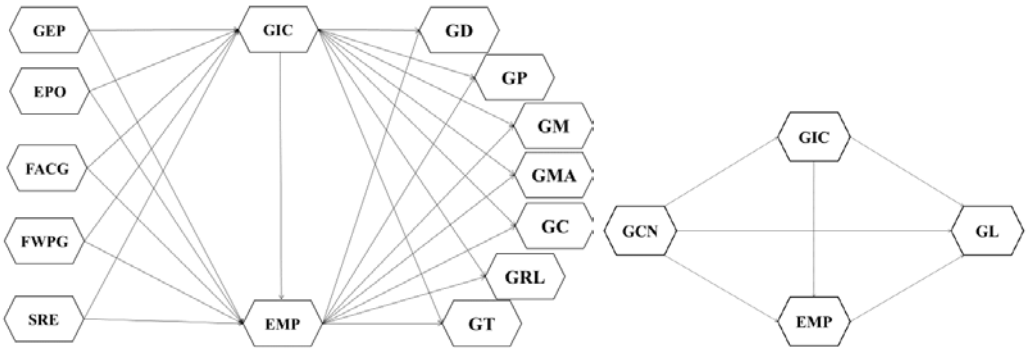


Figure 1 Conceptual Framework (First-order construct: A)

and (Second-order construct: B)

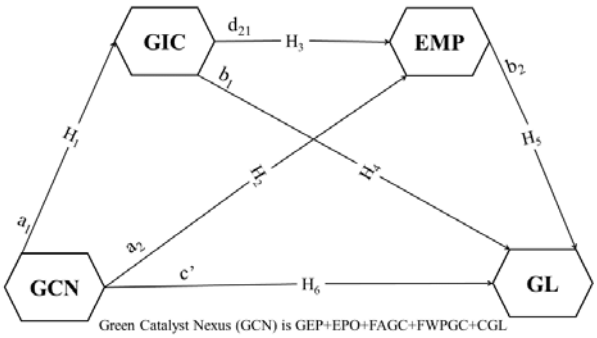


Figure 2 Conceptual Framework (Second-order construct in Standard Form)

Research Hypotheses:

H1: Green Catalyst Nexus (GCN) enhances Green Innovation Capability (GIC).

H2: GCN positively influences Environmental Management Performance (EMP).

H3: GIC positively influences EMP.

H4: GIC positively influences Green Logistics (GL).

H5: EMP positively influences GL.

H6: GCN positively influences GL.

H7: GIC and EMP sequentially mediate the relationship between GCN and GL.

Definition of Terms

Digital Marketing (DM) involves utilizing online platforms, such as social media, mobile apps, and virtual content, to promote property listings. CRLand, for instance, has incorporated WeChat, Douyin, and O2O (online-to-offline) systems to allow virtual tours, live-streamed property launches, and targeted target digital advertising. These tools improve information accessibility and boost consumers' perceived usefulness of the platform (CRLand, 2024).

Personalized Services (PS) include AI-driven property recommendations, smart home previews, and custom buyer journeys tailored to user behavior and preferences. Through big data analytics, CRLand offers dynamic pricing, exclusive offers, and concierge-level interactions, which improve ease of use and relevance of digital interfaces (Bhattacharya et al., 2004).

Experiential Marketing (EM) focuses on emotionally engaging the buyer through immersive, interactive experiences. CRLand utilizes technologies such as VR/AR home viewings, lifestyle-themed events, and interactive model homes to foster emotional connections and brand loyalty. These experiences support deeper psychological involvement in the purchase process, influencing both perceived usefulness and attitude formation

Perceived Ease of Use (PEOU) refers to the degree to which users believe that interacting with the system will be effortless (Davis, 1989). In the real estate context, where transactions involve high complexity and financial significance, platforms that offer intuitive navigation, seamless virtual tours, and real-time assistance become particularly crucial for enhancing PEOU.

Perceived Usefulness (PU) refers to the extent to which users believe that the system will enhance their decision-making or productivity. For property buyers, this includes better access to listings, price comparisons, and tailored property suggestions that address information asymmetry challenges inherent in property markets, thereby improving decision-making quality (Gefen et al., 2003).

Attitude Toward Using (ATU) reflects the user's positive or negative evaluation of using the system. Beyond traditional usefulness and ease of use factors, emotions elicited through experiential marketing directly influence attitude formation toward real estate technology adoption (Bhattacharya et al., 2004).

Behavioral Intention to Use (BI) is the degree to which a person has formulated conscious plans to use a system. It acts as a key predictor of actual engagement (Ajzen, 1991).

Actual System Use (ASU) captures observable user behavior, such as engaging with virtual tours, scheduling property viewings through apps, or interacting with online sales agents. Measuring actual usage in real estate contexts presents unique challenges due to the infrequent nature of property purchases.

Literature Review

Green Supply Chain Management (GSCM) and Green Logistics

GSCM introduces environmental factors into the activities of the supply chain, reducing environmental impact while ensuring the regular operation of the economy (Martínez & Mathiyazhagan, 2020). Green logistics lowers carbon dioxide emissions by enhancing fuel efficiency and streamlining transportation to reduce pollution. It also decreases packaging and storage waste, leading to lower compliance costs (Mohammad & Daniell, 2022). We recognize this can support sustainable development and benefit businesses economically. However, the utilization rate is low due to high costs, limited experience, and varying needs (Li & Zhou, 2024).

Environmental Policy and Institutional Drivers

The government's regulations and policy incentives set standards, provide financial support, and establish the basis for green logistics (Li et al., 2023). The system's mandatory and normative nature pressures enterprises to adopt environmental practices (Daddi et al., 2016). Stakeholder demands, including customer expectations and community concerns, drive the company's move to sustainable logistics. However, implementation faces operational hurdles and higher costs (Yang et al., 2021).

Green Innovation Capability (GIC)

GIC signifies enterprises' capacity to cut pollution and boost competitiveness through eco-friendly products, optimized processes, and improved services (Zhang et al., 2020). The development of GIC can fulfill stakeholder expectations, address diverse market needs, satisfy unique demands, promote green logistics for enterprises, and support sustainable growth (Grazia et al., 2022).

Environmental Management Practices (EMP)

EMP covers environmental policies, audits, training, and testing. Implementing a management plan boosts operational efficiency and performance while reducing pollution (Aslam et al., 2020). Implementing EMP in enterprises boosts regulatory efficiency and compliance. It reduces costs, improves efficiency, enhances competitiveness, market value, and social status (Sroufe, 2003).

The Green Catalyst Nexus (GCN) Framework

The Green Catalyst Nexus (GCN) is an interconnected system driving enterprise sustainability via green innovation and environmental management (Baah et al., 2020; Kalubanga et al., 2024; Khayyat et al., 2024; Kim et al., 2024). The framework has five elements interacting to improve logistics and support sustainable growth via external pressures and internal capabilities. GEP offers regulations and incentives for green practices, motivating sustainability. EPO reflects the firm's strategic commitment to environmental goals. FAGC encompasses cost savings and benefits achieved by meeting standards, which support green investments. FWPG pertains to internal processes that foster environmental goals. SRE concerns stakeholder perceptions and market incentives for sustainability. Together, these components create a system that encourages traditional businesses to pursue environmental sustainability.

Green Logistics (GL)

Green Logistics (GL) optimizes resources and technologies to minimize environmental impact through strategic planning (Mohammad & Daniell, 2022). According to Youngswaing et al. (2024), GL aims to reduce carbon emissions and improve resource efficiency. It comprises seven components: Green Design, Green Procurement, Green Manufacturing, Green Marketing, Green Consumption, Green Reverse Logistics, and Green Transportation. These elements collectively promote environmental sustainability in the logistics chain.

Research Methodology

This article will use quantitative analysis methods for research and analysis. PLS-SEM is suitable for analyzing complex models with latent structures, small samples, and non-normal data distributions, which aligns precisely with the characteristics of this article (Hair et al., 2019).

Sample and Data Collection

Model adequacy is ensured with regard to data exceeding the minimum sample size of 200 obtained via Daniel Soper's SEM calculator (effect size = 0.1; power = 0.80; α = 0.05; latent variables = 14; indicators = 42) because the data consists of environmental management, logistics, and sustainability managers (N=408) practicing at manufacturing firms in Yangzhou, China.

Respondents from manufacturing firms of discrete sizes and sectors in Yangzhou were selected using a stratified sampling approach. Green logistics practices are best known by

managers who manage environmental management, logistics, and sustainability; they have been identified as key informants.

A structured questionnaire survey was used to collect data. Both online and in-person distribution of the questionnaire helped increase the response rate. Respondents were told of the academic nature of the research and that participation was voluntary and anonymous. A total of 408 questionnaires were retained for statistical analysis after screening with respect to question completeness and validity.

Measurement tools

The GCN is modeled as a second-order composite structure, consisting of five first-order dimensions constructed based on Baah et al. (2020), Kalubanga et al. (2024), Khayyat et al. (2024), and Kim et al. (2024). The dependent construct, Green Logistics (GL) (Youngswaing et al., 2024), Green Innovation Capability (GIC) based on Li, N., & Zhou, Y. (2024), and Environmental Management Practices (EMP) based on Al-Minhas et al. (2020), Leung et al. (2023), and Seroka-Stolka (2016).

Data Analysis

The analysis was conducted in two main steps. First, the measurement model was evaluated for composite constructs. For these (formative) constructs, tests for monological validity, the significance of indicator weights (t-statistic > 1.96, $p < 0.05$), and VIF values below 5.0 were performed to prevent multicollinearity. A VIF threshold of less than 3.3 was also used to address common method bias (CMB). Second, the structural model was examined by reviewing path coefficients, t-statistics (above 1.96), p-values, f^2 effect sizes, and R^2 values to determine the model's explanatory power. Model fit was checked using the standardized root mean square residual (SRMR), with values below 0.08 indicating a good fit. The HI99 cutoff ensured differences between observed and model correlations remained acceptable.

Results

Respondent Demographics

The sample was primarily male (86.8%), with females at 13.2%. Most were 18-25 years old (52.5%), then 26–35 (25.0%). Half held master's degrees (50.3%), while fewer had bachelor's (13.7%) or doctorates (4.2%). Most were supervisors or managers (41.7%), then senior staff (31.9%), with fewer in executive (8.1%), entry-level (9.6%), and intermediate roles (8.8%). Over a quarter (26.5%) had over 15 years' experience. Company sizes ranged, with 34.1% in firms of 1,000+ employees, and 20.6% in firms under 50. Manufacturing was the primary sector (50.5%), followed by logistics (19.9%), wholesale/retail (11.0%), and others (18.6%).

First-order construct

Model fit

The model fit for the first-order construct measurement model is shown here. The SRMR value (0.0619) is comfortably below the 0.08 threshold, indicating a good overall fit. Although dULS and dG surpass their HI99 benchmarks, SRMR remains the main criterion in PLS-SEM, confirming the measurement model's adequacy.

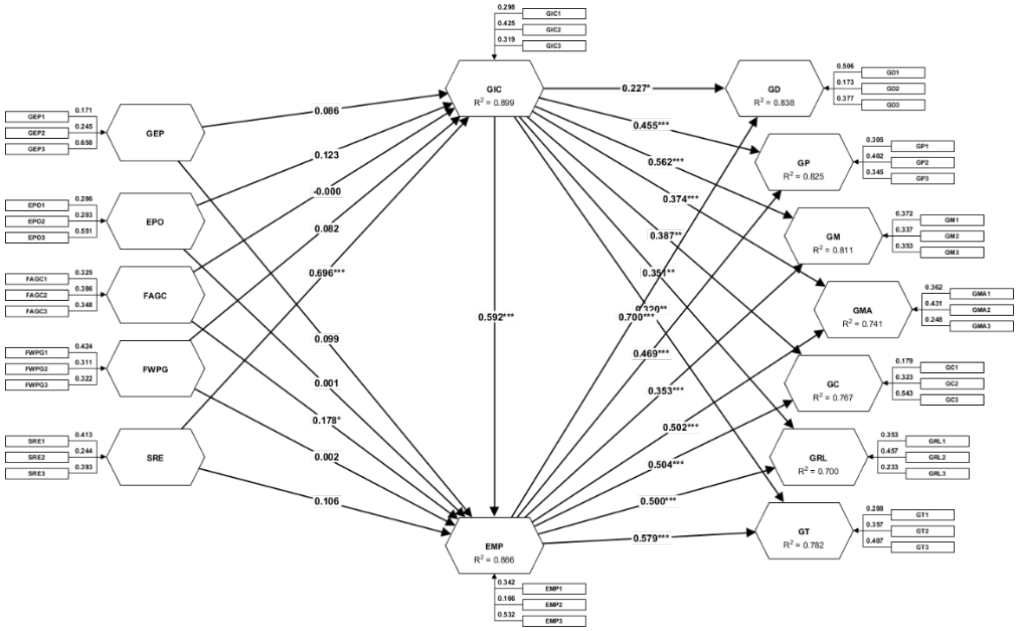


Figure 4: Conceptual model (First-order construct)

Measurement model

Summarizes the measurement quality for the first-order constructs in the composite model. All indicators have strong loadings (> 0.81) and significant outer weights ($t > 1.96$, $p < 0.05$), confirming their meaningful contributions. High-performing indicators like EMP3 (t=10.41) and GIC3 (t=8.65) show strong measurement strength. VIF values range from 2.38 to 4.62, below 5.0, indicating no multicollinearity and that each indicator adds unique variance. All indicators comply with guidelines, with loadings above 0.50 and VIF below 5.0, ensuring a strong measurement model for the structural constructs.

Figure 4 illustrates the measurement model for the first-order constructs, which serve as the basis for forming composite variables. Each construct is measured by multiple formative indicators with strong weights, ensuring measurement integrity.

Second-order construct

Model fit

Table 1 shows an excellent model fit for the composite model. The SRMR value (0.0124) is well below the 0.08 threshold, indicating a strong overall fit. Both dULS (0.0069) and dG (0.0393) are also below their HI95 and HI99 benchmarks, further confirming the model's excellent fit to the data.

Table 1 Model Fit

	Value	HI95	HI99
SRMR	0.0124	0.0156	0.0180
d_{ULS}	0.0069	0.0110	0.0146
d_G	0.0393	0.0647	0.0837

Measurement model

The assessment of the second-order composite constructs shows strong indicator loadings (all > 0.87) and significant outer weights ($p < 0.05$), confirming their contributions to the constructs. T-statistics were consistently high, demonstrating robust measurement quality. VIF values (2.42–4.64) remained well below the threshold of 5, indicating no multicollinearity issues. Overall, the results confirm the reliability and validity of the second-order measurement model.

Table 2: Measurement Model for Second-Order Constructs of the Composite Model

Indicator	Loading	Weight	T-statistic of Weight	Variance inflation factors (VIF)
GIC1	0.9415	0.4106	6.1170	3.4804
GIC3	0.9755	0.6288	9.7465	3.4804
EMP1	0.9546	0.4420	7.0654	3.9593
EMP3	0.9750	0.5928	9.4229	3.9593
GEP	0.8761	0.3001	5.3430	2.4278
SRE	0.9813	0.7511	14.5942	2.4278
GD	0.9790	0.6498	9.4897	3.6987

Indicator	Loading	Weight	T-statistic of Weight	Variance inflation factors (VIF)
GMA	0.9110	0.1796	2.4010	4.6400
GRL	0.8974	0.2232	3.0002	3.9730

Structural Model Results Summary

The structural model analysis reveals significant relationships across most hypothesized paths, with five of six direct effects receiving empirical support.

Strong Direct Effects: Green Corporate Networks (GCN) strongly influence Green Innovation Capability (β = 0.922, $p < 0.001$), making it the main factor. Environmental Management Practices (EMP) significantly impact Green Logistics (β = 0.592, $p < 0.001$), highlighting management's role. Green Innovation Capability also boosts EMP (β = 0.607, $p < 0.001$), supporting the innovation-to-implementation link.

Moderate Direct Effects: Green Corporate Networks directly influence both Environmental Management Practices (β = 0.347, $p < 0.001$) and Green Logistics (β = 0.275, p = 0.0015), demonstrating the broad impact of policy and institutional networks.

Table 3 Structural Model, Both Direct and Indirect Effects

Hypothesis	Original coefficient	Standard bootstrap results				Percentile bootstrap quantiles		f^2	Supported
		Mean value	Standard error	t-value	p-value (2-sided)	2.5%	97.5%		
Direct effect									
H1: GCN -> GIC	0.9220	0.9224	0.0158	58.3137	0.0000	0.8889	0.9495		Yes
H2: GCN -> EMP	0.3470	0.3427	0.0811	4.2767	0.0000	0.1772	0.5011		Yes
H3: GIC -> EMP	0.6074	0.6126	0.0806	7.5323	0.0000	0.4533	0.7734		Yes
H4: GIC -> GL	0.0836	0.0856	0.0967	0.8641	0.3876	-0.1032	0.2739		No
H5: EMP -> GL	0.5923	0.5926	0.0805	7.3578	0.0000	0.4323	0.7491		Yes
H6: GCN -> GL	0.2751	0.2737	0.0864	3.1839	0.0015	0.1031	0.4389		Yes

Hypothesis	Original coefficient	Standard bootstrap results				Percentile bootstrap quantiles		f^2	Supported
		Mean value	Standard error	t-value	p-value (2-sided)	2.5%	97.5%		
Indirect effect									
GCN -> GL	0.6143	0.6169	0.0802	7.6576	0.0000	0.4635	0.7766	0.6143	Yes
GCN -> EMP	0.5600	0.5651	0.0756	7.4033	0.0000	0.4194	0.7190	0.5600	Yes
GIC -> GL	0.3598	0.3626	0.0674	5.3390	0.0000	0.2419	0.5040	0.3598	Yes

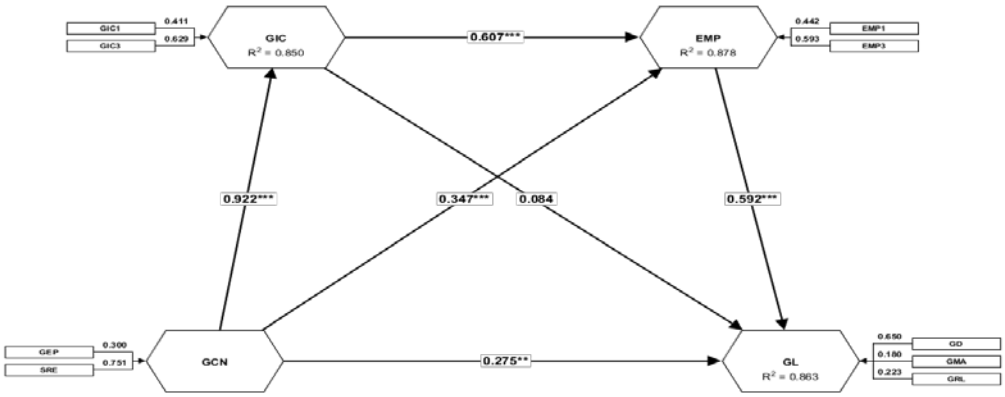


Figure 5 Structural Model Results

Non-Significant Path: Green Innovation Capability shows no direct effect on Green Logistics (β = 0.084, p = 0.388), suggesting that innovation requires mediation through management practices to influence logistics outcomes.

Mediation Effects: All three indirect pathways are significant, showing intense mediation where Green Corporate Networks influence outcomes via Green Innovation Capability and Environmental Management Practices. The results support a model where corporate networks drive innovation, improve management practices, and enhance logistics performance.

These results demonstrate partial mediation effects: although GCN has a direct path to Green Logistics (H6), a significant part of its effect is mediated through GIC and EMP. Similarly, GIC does not directly influence GL (H4 is not supported), but it has a strong indirect effect via EMP. This confirms the hypothesis in the conceptual framework that environmental drivers impact logistics performance both directly and by enhancing innovation capability and management practices.

Discussion

The findings show that the Green Catalyst Nexus (GCN), comprising policy, demand, incentives, and strategy, boosts green logistics performance directly and through Green Innovation Capability (GIC) and Environmental Management Practices (EMP). The important path from GCN to GIC and EMP confirms that external pressure and internal strategic consistency can drive companies to adopt green logistics practices (Yang et al., 2021). The model also shows strong explanatory power. **GCN explains 85.0% of the variance in GIC (R^2 = 0.850).** GCN and GIC explain **87.8% of the variance in EMP (R^2 = 0.878).** GCN, GIC, and EMP together explain **86.3% of the variance in green logistics performance (R^2 = 0.863).** These values indicate that the model has high predictive capability. GIC has little direct impact on green logistics but can influence it indirectly through EMP. Innovation alone is not enough; combining it with management is essential for sustainable development (Grazia et al., 2022; Hair et al., 2019). These results suggest that companies should adopt a comprehensive policy and strategy approach while strengthening innovation and management to achieve sustainable logistics. Previous studies also show that green logistics practices improve sustainable inventory management and operational performance in supply chains (Dissorn, 2018).

Theoretical Implications

This study contributes to the literature on green logistics and sustainable supply chains. It proposes the **Green Catalyst Nexus (GCN)** as a composite framework that links environmental policy drivers, organizational innovation, and management practices. The findings show that **Green Innovation Capability (GIC) does not directly improve green logistics performance**. Instead, it affects performance through **Environmental Management Practices (EMP)**. This result highlights the importance of management systems in transforming innovation into operational sustainability. The study, therefore, extends existing research by showing that innovation and management must work together to drive green logistics performance**.**

Practical Implications

The findings provide practical insights for managers and policymakers in the manufacturing sector. Firms should strengthen environmental management systems to translate green innovation into logistics performance. Managers should integrate green innovation, environmental management, and logistics strategy to achieve sustainable outcomes. Government agencies can support green logistics by providing policy incentives, regulatory support, and financial programs that encourage firms to adopt environmentally responsible practices.

Limitations

This study still has some issues and limitations. First, it uses cross-sectional survey data without considering the element of time, so the survey results lack dynamism. Second, the sample size is limited to China's manufacturing industry, which overlooks other sectors and results in less comprehensive research. Third, there may be some deviations in data calculation and collection, and there could also be common method biases in the process (Philip et al., 2023

Recommendations for Future Research

Future research should shift: 1. From horizontal to vertical design, considering changes over time. 2. Expand beyond logistics to other industries, departments, and countries for broader insights. 3. Deepen study on company factors like size, ownership, environmental uncertainty, and mechanisms such as culture or stakeholder participation. These efforts will lead to more extensive research, promoting enterprise development and economic growth.

Conclusion

This study indicates that: 1. The Green Catalyst Relationship (GCN) - including policy, market, financial, and organizational drivers - directly and indirectly affects the green logistics performance of China's manufacturing industry through Green Innovation Capability (GIC) and Environmental Management Practices (EMP), which is a significant impact. 2. Verified the mediating role of GIC and EMP. Because GCN can directly enhance EMP or enhance EMP through GIC, thereby improving logistics outcomes (Hair et al., 2019; Yang et al., 2021).

These contents have identified external driving factors that affect logistics and the role of internal capabilities. These play an important role in achieving sustainable logistics for enterprises. This article also demonstrates their interactions and contributes to the literature. These theories guide environmental policy makers and implementers. It has pointed out the direction for enterprises to achieve long-term development. This provides ideas for enterprises to strengthen innovation and management practices and promote the achievement of sustainable development goals (Mohammad & Daniell, 2022; Wei et al., 2023).

Future research should adopt **longitudinal designs** to examine changes over time. It should also expand the study to other industries and regions. Future studies may further explore additional mediating and moderating variables to deepen the understanding of green supply chains.

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